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Design of a Microcontroller Based Electromagnetic Crane for Small Scale Applications

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Abstract

This paper discerns key ideas and themes of a two dimensional prototype tower crane designed to pick up a metallic object and place that in a prefixed location with a befitting electromagnet manipulated by a robust microcontroller. The proposed crane is powered by two stepper motors one for vertical movement and another for horizontal movement where both steppers are controlled with a powerful and programmable microcontroller. Both The vertical scale up and scale down are programmable with 3600 freedom of horizontal rotation. Stepper motor provides with precise control over the crane and high holding torque. Microcontroller reduces the complex circuitry and provides with robust flexibility to change vertical elevation and angle of rotation. An AC Electromagnet with necessary shielding is used to pick targeted thing. The proposed designed has practically constructed with one NEMA8 and One NEMA 11 stepper motors that work fine with holding torque 4 oz-inch. This prototype version is transformable into a system with the holding torque up to 50N-m. It is designed for small scale operation such as to move things in a manufacturing yard, car assembly line etc.

Keywords: Conventional Crane, Stepper Motor, Microcontroller, Electromagnet

1. INTRODUCTION

A crane is a machine that is capable of raising and lowering heavy objects and moving them horizontally. Cranes are distinguished from hoists, which can lift objects but that cannot move them sideways. Microcontroller based electromagnetic crane is a prototype version to replace the conventional human operated crane for small scale operation. It has numbers of advantages over conventional one. As it is operated by a robust microcontroller based program thus it works with great efficiency and provides flexibility to control movement. As it is robotic it reduces monthly payment for operators. Stepper motor provides higher holding torque and high precision where power consumption is very low. Its degree of rotation is fixed but programmable in opposite to human operated crane. Due to electromagnetic it can pick only metallic things.

2. SURVEY

Table 1: Survey between conventional crane and electromagnetic crane.

Conventional Crane	*Electromagnetic crane*
Human operated that means Analog system	Microcontroller controlled that means Digital system
Any type of material can handle	Metallic things only
Less control over movement	Absolute control over movement
It uses mostly induction motor	Stepper motor is used
Motors longevity relatively low	Motors longevity relatively high
Design for any weight lifting	Design for precise small weight lifting
Maximum weight lifting capacity depends on design	Maximum weight lifting capacity with stepper motor is 50n-m
Operating cost high	Operating cost low
Initial cost relatively low	Initial cost high
Relatively high maintenance	Low maintenance

Table 1 represents the survey between conventional crane and electromagnetic crane.

3. SYSTEM DESIGN

3.1. Hardware

This is a tower type crane. This prototype version is a wooden structure though for actual use that must be constructed with steel. The mast [1] of this crane is designed with three legs for better balancing. On the top of mast a well-designed platform is placed to support jib [2], stepper motor, counter weight [3], controlling circuit etc. Two stepper motors is used in this design. One stepper motor is placed on the raised platform. It is responsible for horizontal movement of the jib. To balance the crane a counterweight is also used. The other stepper motor is used to scale up and scale down the electromagnet which is used to pick up the things.

An AC electromagnet coupled with a VARIAC [4], the variable autotransformer, is used to pick up metallic things. The VARIAC helps to control current and voltage to the electromagnet which ultimately shape the power of the electromagnet. Controlling circuit, the striking features of this design, is designed with a robust pic16F84A [5] microcontroller. Microcontroller generates necessary controlling signal. With the help of other circuit this signal is translated into movement of various parts of the crane. Total circuit is enclosed in a metallic box to shield the electromagnetic field [6] produces in the electromagnet. For practical purpose more effective shielding is required.

3.2. Circuit Diagram

Fig. 1 represents the circuit diagram of the controlling circuit of the developed electromagnetic crane.

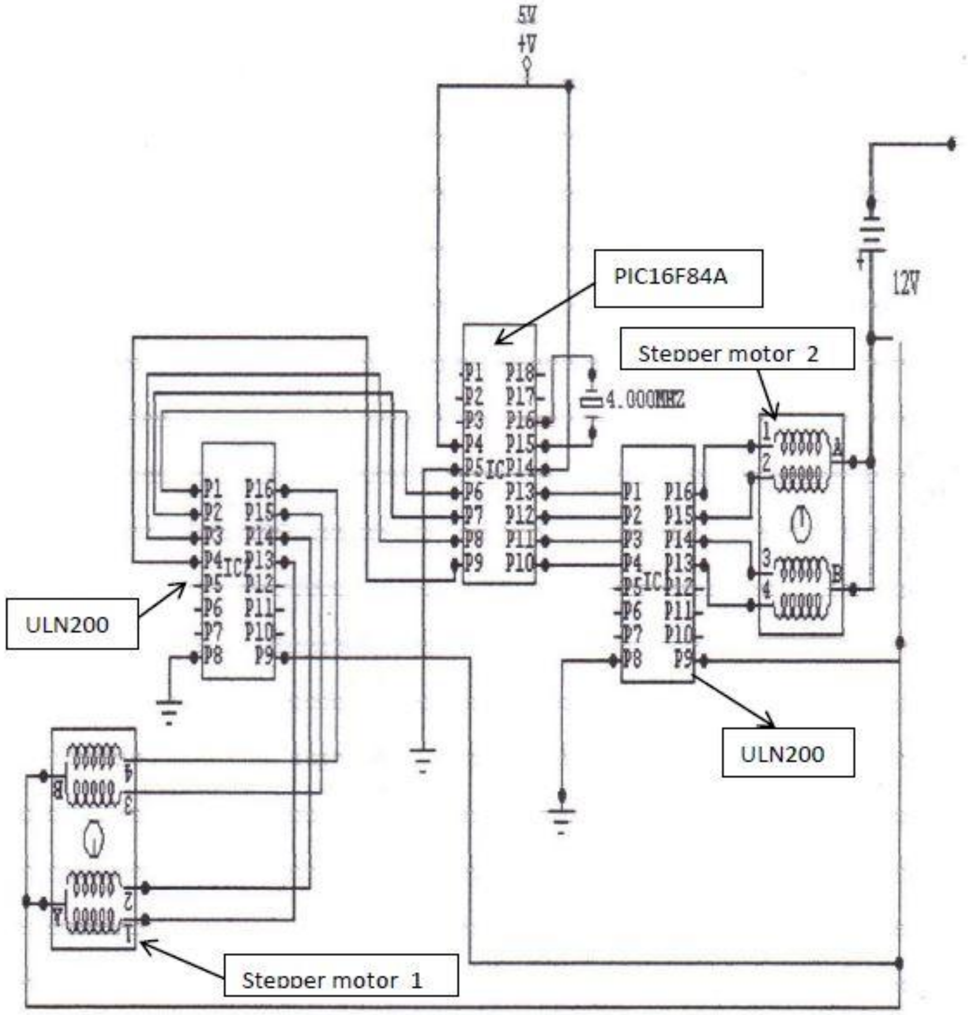

Fig. 1: Controlling Circuit Diagram

3.3. Software

3.3.1. Algorithm of the program

Algorithm of the program is given below:

Step-01: Microcontroller port initialization
Step-02: Start main function
Step-03: Declare All Ports of A and B as output
Step-04: Start a loop to get down the electromagnet
Step-05: Turn on electromagnet
Step-06: Start a loop to lift the electromagnet with object
Step-07: Start a loop to rotate slewing unit/jib to a predetermined angle
Step-08: Start a loop to lower the electromagnet
Step-09: turn off electromagnet
Step-10: Start a loop to lift the electromagnet object
Step-11: Start a loop a revert the slewing unit/jib to the starting position
Step-12: Go to step-04

3.3.2. Flowchart Fig. 2 represents the flowchart of the developed program for the microcontroller.

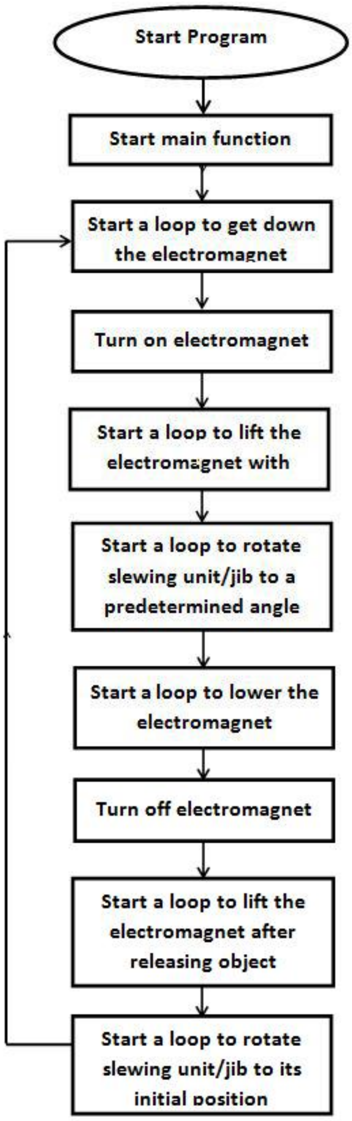
Start Program
Start main function
Start a loop to get down the electromagnet
Turn on electromagnet
Start a loop to lift the electromagnet with
Start a loop to rotate slewing unit/jib to a predetermined angle
Start a loop to lower the electromagnet
Turn off electromagnet
Start a loop to lift the electromagnet after releasing object
Start a loop to rotate slewing unit/jib to its initial position

Fig. 2: Flowchart of the developed program for the microcontroller.

4. EXPERIMENTAL DETAILS

Table 2: Required components and materials specifications

Height of the tower or mast	1′
Length of slewing unit/jib	9″
Stepper motor size for vertical motion	8 NEMA
Radius of Cable drum	1″
Holding torque of Stepper motor for vertical motion	4 oz-inch
Pull out torque of Stepper motor for	3.5 oz-inch at 3000PPS [7]
Distance between weight and pivot point	5″
Distance between counter balance and pivot	4″
Counter balance	5 oz
Stepper motor size for horizontal motion	NEMA 11
Holding torque of Stepper motor for horizontal motion	4 oz-inch
Pull out torque of Stepper motor for horizontal motion	3.5 oz-inch at 3000PPS
Microcontroller type	PIC16F84A
Programming language used	Assembly language [8]
Electromagnet type	AC electromagnet

Table 2 represents the specifications of the required components and materials used in the system.

6. RESULTS AND DISCUSSION

The aim of this design is to automate and precise control not to boost weight lifting capacity of a manual crane. We have achieved precise control over the crane movement with the sacrifice of weight lifting. The crane with one NEMA 08 and one NEMA 11 stepper motors can pick 4 oz-inch successfully and can place it after moving a preprogrammed angle. Vertical elevation and horizontal degree of rotation can be fixed only by changing program. Due to unavailability of high power stepper motor it is tough to enhance weight lifting capacity of this crane. The Electromagnetic shielding is inevitable, absence of which may hinder smooth operation of microcontroller.

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REFERENCES

[1] http://www.craneblogger.com/crane-resource-library/how-are-tower-cranes-built/
[2] http://www.morrow.com/crane101
[3] http://www.ehow.com/how_10022172_calculate-counterbalance-weights.html
[4] http://www.tech-faq.com/variac.html
[5] http://www.microchip.com/wwwproducts/Devices.aspx?product=PIC16F84A
[6] http://www.lessemf.com/mag-shld.html
[7] www.acpd.co.uk/.../stepping%2
[8] http://www.mikroelektronika.co.yu/english/product/books/PICbook/4_Poglavlje.htm(1-15)